

# Time Will Tell: Long-term Observations of the Response of Rocky-Habitat Fishes to Marine Reserves in Puget Sound

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## Abstract

The Washington Department of Fish and Wildlife has established a series of marine reserves in Puget Sound and the San Juan Archipelago that have prohibitions on the harvesting of bottomfishes. Most of these reserves are located where rocky habitats predominate, and now account for 15% of the available nearshore rocky habitat in some sub-basins. The rockfishes (genus *Sebastes*), lingcod (*Ophiodon elongatus*), and other species attracted to rocky habitats have been monitored at a number of these sites with a variety of visual census techniques. Some reserves sites and comparable fished areas have been monitored since 1992.

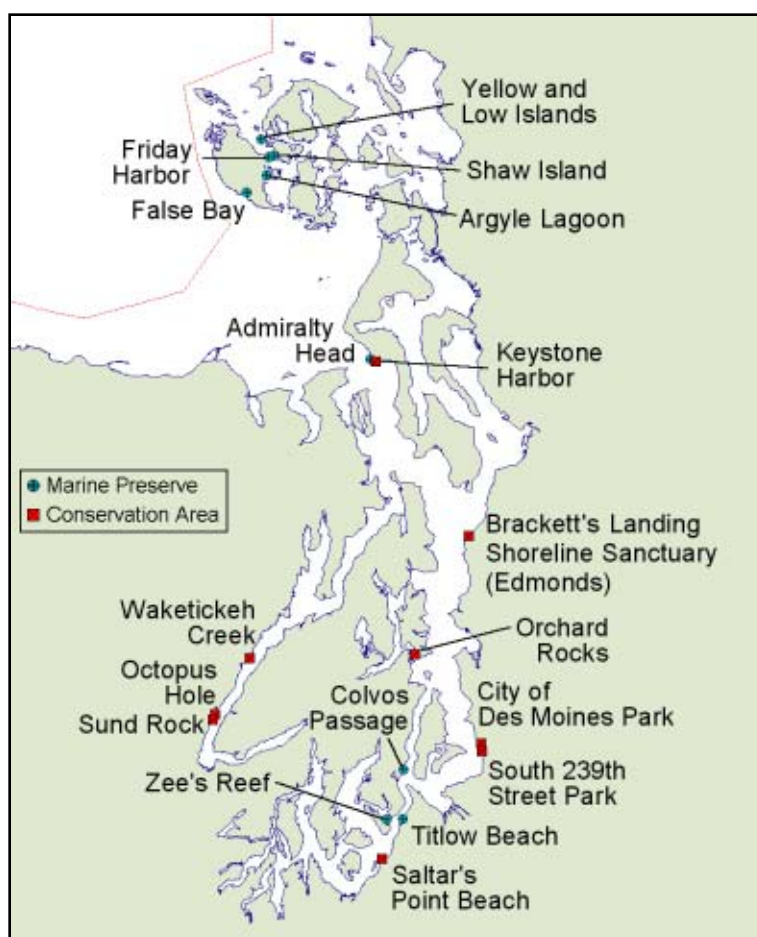
At Brackett's Landing (formerly Edmonds Underwater Park), a reserve established in 1970, large copper and quillback rockfish were in far greater abundance between 1993 and 1997 than at nearby fished sites. However, after a hiatus in monitoring, rockfish densities were found to have declined dramatically at the long-term marine reserve. The densities of large lingcod, however, appeared to have not changed substantially at Brackett's Landing during the same period. At reserve sites in the San Juan Archipelago, rockfish densities have not changed dramatically from the densities observed during the mid-1990s. In contrast, lingcod densities at reserve sites in the San Juans have substantially increased since 1990s and large lingcod have become more abundant during the winter spawning period. While lingcod densities have also increased in comparable fished areas in the San Juans, large lingcod and nesting activity is relatively low and unchanged. In Hood Canal, where a series of reserves was created beginning in 1994, rockfishes have become relatively more abundant and larger since monitoring began in 1996. The differing patterns in fish abundance observed at long-term and newly-created reserves may be due to the age of reserve, size, natural substrate, and degree of fishing and disturbance.

## Introduction

The Washington Department of Fish and Wildlife (WDFW) has established a series of no-take marine reserves in Puget Sound and the San Juan Archipelago that have prohibitions on the harvesting of bottomfishes and other marine resources (Figure 1). Some of these reserves are conservation areas that have prohibitions for the removal of any marine wildlife or fish and Marine Preserves that have prohibitions on the harvest of fish and other marine species. Most of these reserves are located where rocky habitats predominate, and one reserve has been in existence since 1970 (Table 1). Previous monitoring of some of the reserves containing rocky habitat has demonstrated that rockfishes (Genus *Sebastes*) and lingcod (*Ophiodon elongatus*) can occur in higher densities and larger sizes than in comparable, nearby fished areas (Palsson and Pacunski 1995; Palsson 1998). WDFW has continued monitoring these reserves in order to examine temporal trends in fish density and size.

## Methods

Rockfishes, lingcod, and other species attracted to rocky habitats have been monitored at several reserves and fished sites with a variety of visual census techniques (Table 2). Some reserves sites and comparable fished areas have been monitored since 1992 and most of these monitored sites have been visited until 2002. Three visual survey techniques using scuba divers have been employed including line transects for lingcod, strip transects for key bottomfish species, and complete censuses of key species living on small rocky outcroppings. All techniques used two divers who counted fish along permanent baselines set in rocky habitats with high vertical relief and among a diversity of macro- and microhabitats including cobbles, boulders, and walls. The lingcod line transect method was patterned after LaRiviere (1981) who counted all lingcod and their nests along a 250 m path. The width of the line transect was one half of the measured black-body visibility measured at depth. The line transects were primarily conducted during the winter spawning period and at initially one site within the Friday Harbor Marine Preserve and at one site at the Turn Island fished area. Beginning in 1995, one additional transect was added at each Turn Island and at the Friday Harbor Preserve. At the Friday Harbor, Brackett's Landing, and Orchard Rocks reserves and their corresponding fished sites strip transects, patterned after Matthews (1990), were conducted by divers counting all fish within a 90 m length by 3 m width corridor. The three reserves and one fished site in Hood Canal consist of small rocky outcroppings at which the area dimensions



**Figure 1.** Washington Department of Fish and Wildlife Marine Preserves and Conservation Areas in Puget Sound.

have been measured. Since 2001, complete censuses of rockfish, lingcod, and other key bottomfish have been conducted during the autumn at these sites. All observations of fish regardless of survey method included either direct measurements of fish length to the nearest 10 cm size group or approximations of length based upon the diver's experience.

All fish count and lingcod nest data were transformed to density observations based upon their respective survey design. Only information for copper rockfish (*Sebastes caurinus*) and lingcod were used. The analysis of fish size was conducted by comparing densities of large rockfish in the 40 cm or larger size classes and large lingcod in the 70 cm or greater size class among reserve and fished area treatments and among years. These data were compared using analysis of variance techniques applied to the density observations and to the square-root transformed densities.

## Results

Detailed results and analyses will be presented elsewhere. A summary of our results shows that in most comparisons, copper rockfish and lingcod densities were greater in the reserves than in the comparable fished areas (ANOVA,  $p < 0.05$ ). Differences in rockfish densities were not observed between the Orchard Rocks Conservation Area and the Point Glover Fished Area and between lingcod densities at the Octopus Hole Conservation Area and the Jorstad Creek fished area. The densities of large copper rockfish were only greater between the Brackett's Landing (formerly known as the Edmonds Underwater Park) and central Puget Sound fished areas. Lingcod were larger in the San Juan and central Puget Sound comparisons and were not tested among Hood Canal treatments because of low sample sizes.

Several patterns emerged when examining inter-annual trends in density and sizes within the reserves examined. The density of copper rockfish of all sizes and large copper rockfish at the Brackett's Landing reserve decreased substantially between 1995 and 1997 and 1999 and 2002 time periods while the densities of lingcod of all sizes and large lingcod increased between the two time periods. Inter-annual trends in copper rockfish densities and sizes were not evident at the

**Table 1.** Monitoring Scheme for Puget Sound Marine Reserves.

Reserve	Year Created	Survey Type	Years Monitored	Frequency/ Year	Fished Area Comparison
<b>San Juan Archipelago</b>					
Friday Harbor Marine Preserve	1990	Lingcod Line Transect	1992-2002	1-4	Turn Island
Friday Harbor Marine Preserve	1990	Strip Transect	1994-5, 1997-8, 2001	4-8	Turn Island
<b>Central Puget Sound</b>					
Brackett's Landing Conservation Area	1970	Strip Transect	1995-7 1999-2002	6	Boeing Creek, Port Blakely, Blake Island, Orchard Rocks
Orchard Rocks Conservation Area	1998	Strip Transect	1995-7 1999-2002	6	Point Glover
<b>Hood Canal</b>					
Waketickah Conservation Area	2000	Census	2001-2	2	Jorstad Creek
Octopus Hole Conservation Area	1994	Census	2001-2	2	Jorstad Creek
Sund Rocks Conservation Area	1994	Census	2001-2	2	Jorstad Creek

Orchard Rocks and Friday Harbor marine reserves, but increasing lingcod densities over time were detected at these two reserves. Large lingcod densities increased over time at the Friday Harbor reserve but not at the Orchard Rocks reserve. Insufficient temporal data was available for analyzing the Hood Canal reserves, but mean lengths of copper rockfish appear to be increasing over time at all three reserves and at the fished site.

**Table 2.** Summary of Puget Sound Reserve Monitoring Results.

Reserve	Copper Rockfish Density	Rockfish Size	Lingcod Density	Lingcod Size
Friday Harbor Marine Preserve	Higher than Fished Area, No trend	No difference with Fished Area, No trend	Higher than Fished Area, Increasing trend	Higher than Fished Area, Increasing trend
Brackett's Landing Conservation Area	Higher than Fished Area, Decreasing trend	Higher than Fished Area, Decreasing trend	Higher than Fished Area, Increasing trend	Higher than Fished Area, No trend
Orchard Rocks Conservation Area	No difference, no trend	No difference	Higher than Fished Area, Increasing trend	Higher than Fished Area, No trend
Waketickah Conservation Area	Higher than Fished Area	No difference, Increasing all areas	Higher than Fished Area	
Octopus Hole Conservation Area	Higher than Fished Area	No difference, Increasing all areas	No difference	
Sund Rocks Conservation Area	Higher than Fished Area	No difference, Increasing all areas	Higher than Fished Area	

## Discussion

Copper rockfish and lingcod occurred at higher densities in most marine reserves in Puget Sound than in nearby and comparable fished areas. The comparisons for large copper rockfish densities were not higher in most reserves than the fished areas, but most reserves had higher densities of large lingcod than fished areas. The Brackett's Landing reserve was the exception where large copper rockfish occurred in higher densities than at the comparable fished sites. These conclusions are consistent with the earlier observations described by Pálsson and Pacunski (1995) and Pálsson (1998) which are among the first describing the response of temperate fishes in the northeastern Pacific to marine reserves. Eisenhardt (2000) conducted more intense monitoring at reserves in the San Juan Archipelago including the Friday Harbor Marine Preserve and two other reserves in the San Juan Archipelago. He found that more large copper rockfish occurred in the reserves than at Turn Island and two other fished areas. This result contrasts with the pattern observed in our study, but the difference may be due to more the more intensive study performed by Eisenhardt resulting in greater statistical power. Paddock and Estes (2000) also observed that rockfishes in central California reserves were larger compared to the paired fished area in two of three comparisons. These two reserves with larger fish had a longer duration in reserve status than the third reserve that did not have larger fish than the matched fished area. Paddock and Estes' pattern of more large fish in older reserves is similar to the pattern at Brackett's Landing indicating a size response in slow-growing rockfish may take time to achieve. They, however, did not find differences in rockfish densities among the treatments, but they did find that estimated biomass and reproductive potential were greater in the reserves compared to fished areas.

Our results found that although copper rockfish densities were higher in most reserves than fished areas, copper rockfish densities did not increase with longer durations in reserve status. This result contrasts with the worldwide trend of positive increases in fish abundance in marine reserves (Halpern 2003). We found that rockfish densities decreased with time in the long-term reserve at Brackett's Landing. Lingcod, however, were found to be increasing in most Puget Sound reserves suggesting increased lingcod abundance may be suppressing copper rockfish populations. Such species interactions may be occurring through direct predation by lingcod on rockfish or perhaps lingcod out-competing rockfish for prey items. These trophic interactions have been implicated in structuring the fish and invertebrates in other marine reserves (Babcock et al. 1999; Salomon et al. 2002) and warrant further investigation in Puget Sound.

Other factors besides trophic interactions may explain the changing patterns of copper rockfish abundance and lingcod in Puget Sound. Fishery management practices have changed during the past decade to promote the recovery of lingcod and more recently to decrease the fishery impacts on rockfish populations. Fishery catch rates for lingcod have dramatically improved in recent years indicating greater populations of lingcod (PSAT 2002). The expected differences between reserve and fished area treatments may be less since fishery managers reduced the daily allowable take of rockfish to one. This change in management has greatly reduced the targeted fishery on rockfish and may result in the rockfish populations in fished areas becoming similar to those in reserve areas. These changes in management practices may induce unstable patterns in fish communities whereby rockfish may initially increase inside and outside reserves but may be later suppressed as lingcod predation or competition predominates in the system.

Our results warrant continued monitoring of marine reserves and fished areas in Puget Sound and call for expanded studies examining the predator and prey interactions of fish and invertebrate communities. Fishery managers must be sensitive to the impacts of harvest regulations that may unnaturally favor one keystone species over other community members.

## Acknowledgements

This work has been supported by Sport Fish Restoration Act funds and is currently supported by state funds for the Recovery of Puget Sound Marine Fish.

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